

Unit 10: Redox

CDO IB Chemistry SL/HL

Assessment Statements

- I. Introduction to Oxidation Reduction
 - a. Define oxidation and reduction in terms of electron loss and gain.
 - b. Deduce the oxidation number of an element in a compound.
 - c. State the names of compound using oxidation numbers.
 - d. Deduce whether an element undergoes oxidation or reduction in reactions using oxidation numbers.
- II. Redox Equations
 - a. Deduce simple oxidation and reduction half-equations given the species involved in a redox
 - b. Deduce redox equations using half-equations. H^+ and H_2O should be used where necessary to balance half-equations in acid solution.
 - c. Define the terms oxidising agent and reducing agent
 - d. Identify the oxidising and reducing agents in redox
- III. Reactivity
 - a. Deduce a reactivity series based upon the chemical behaviour of a group of oxidising and reducing agents. Examples include displacement reactions of metals and halogens.
 - b. Deduce the feasibility of a redox reaction from a given reactivity series.
- IV. Voltaic Cells
 - a. Explain how a redox reaction is used to produce electricity in a voltaic cell. This should include a diagram to show how two half-cells can be connected by a salt bridge to form a whole cell.
 - b. State that oxidation occurs at the negative electrode (anode) and that reduction occurs at the positive electrode
- V. Electrolytic Cells
 - a. Describe, using a diagram, the essential components of an electrolytic cell.
 - b. Describe how current is conducted in an electrolytic cell
 - c. Deduce the products of the electrolysis of a molten salt.

Oxidation and Reduction

- More Fundamental definition
 - Oxidation –
 - Reduction –

- In an

Oxidation Numbers

- In order to keep track of what
- There are two parts two oxidation numbers:
 - Sign –
 - Value –

Assigning Oxidation Numbers

1. Elements in their elemental form have an oxidation number of 0.
2. The oxidation number of simple ions are the same as its charge.
3. The usual oxidation number is the same as the charge of the most common ion

Element	Usual Oxidation Number	Exceptions
Na, K		
F		
O		
H		
Cl		

4. The sum of the oxidation numbers in a neutral compound is 0.
5. The sum of the oxidation numbers in a polyatomic ion is the charge on the ion.
6. Assign oxidation numbers for the atoms that are easy to do then use rules 4 and 5 to find other by difference

Example 1: Calculating Oxidation Numbers



Redox Reactions

- A redox reaction is
- Reactions that are always redox
 - Combustion –
 - Synthesis –
 - Ions
 - Ions

Oxidation and Reduction

- A species is oxidized when it loses electrons.
 - Here, zinc loses two electrons to go from neutral zinc metal to the Zn^{2+} ion.
- A species is reduced when it gains electrons.
 - Here, each of the H^+ gains an electron, and they combine to form H_2 .

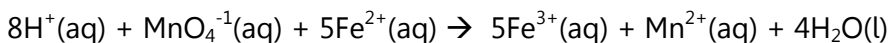
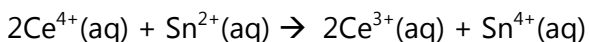
Oxidation and Reduction

- What is reduced is
 - H^+ oxidizes Zn by taking electrons from it.
- What is oxidized is

- Zn reduces H^+ by giving it electrons.

Example 1

Indicate which of the reactants is reducing and which is oxidizing



Balancing Redox Equations

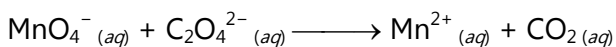
- Perhaps the easiest way to balance the equation of an oxidation-reduction reaction
- This involves treating (on paper only) the oxidation and reduction as

The Half-Reaction Method (Acid)

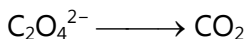
1. Combine like compounds and write each half reaction
2. Balance each half-reaction.
3. Balance elements other than H and O.
4. Balance O by adding H_2O .
5. Balance H by adding H^+ .
6. Balance charge by adding electrons.
7. Multiply the half-reactions by integers so that the electrons gained and lost are the same.
8. Add the half-reactions, subtracting things that appear on both sides.
9. Make sure the equation is balanced according to mass.
10. Make sure the equation is balanced according to charge.

The Half-Reaction Method

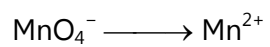
Consider the reaction between MnO_4^- and $\text{C}_2\text{O}_4^{2-}$



Oxidation Half-Reaction

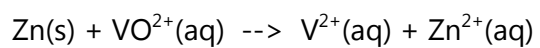


Reduction Half-Reaction

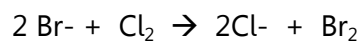


Combining the Half-Reactions

Example



Example: Balancing Half Equations



Reactivity Series

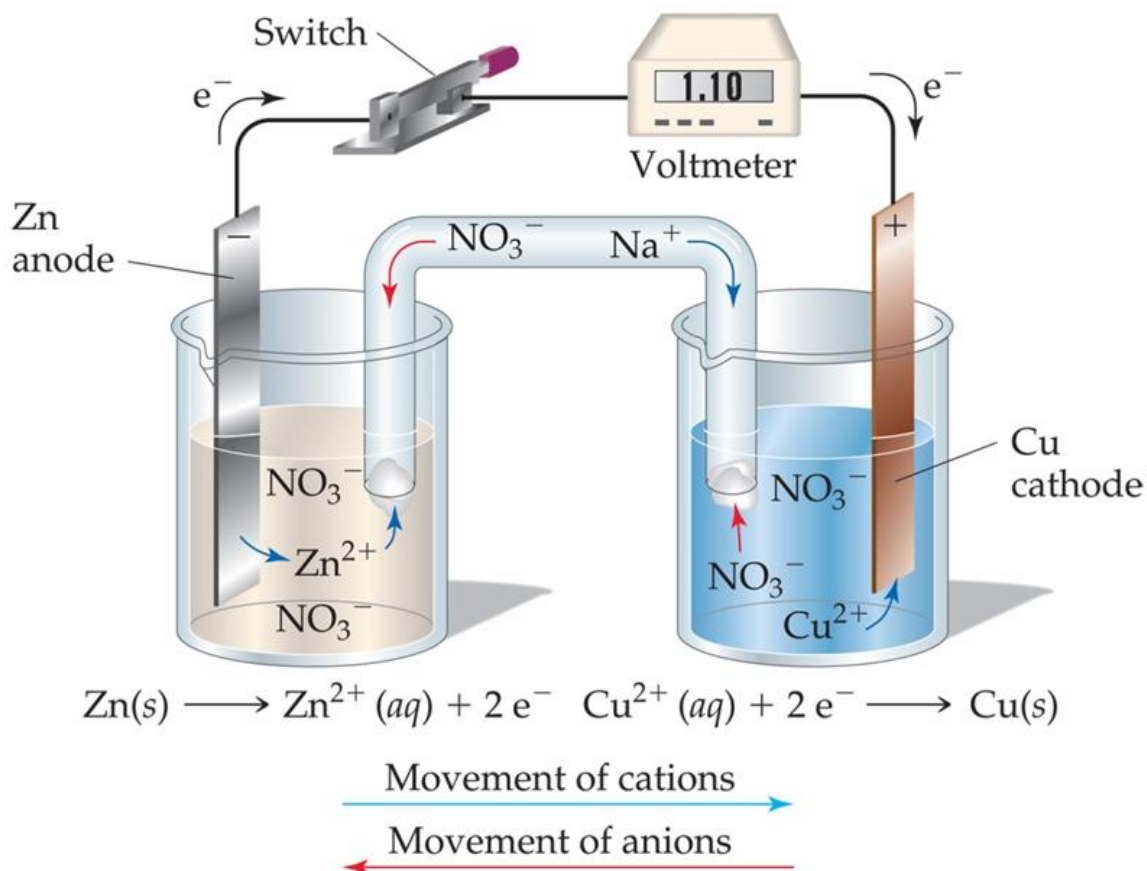
- Metals can be arranged
- Metal of higher reactivity
- Example: Zinc and Copper
- Metals above H –
- Example: Mg and H⁺

Reactivity of Halogens

- The halogens can be similarly arranged
Chlorine
Bromine
Iodine
- Example: Chlorine reacts with potassium bromide

Voltaic Cells

- A voltaic cell allows
- A voltaic cell allows a
- In a cell the two half reactions are



- The oxidation occurs
- The reduction occurs
- Once even one electron flows from the anode to the cathode,
- Therefore, we use a salt bridge, usually a U-shaped tube that contains a salt solution,
 - Cations move
 - Anions move

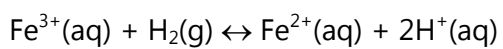
- In the cell, then,
- As the electrons leave the anode,
- As the electrons reach the cathode,
- The electrons are taken by the

Cell Notation

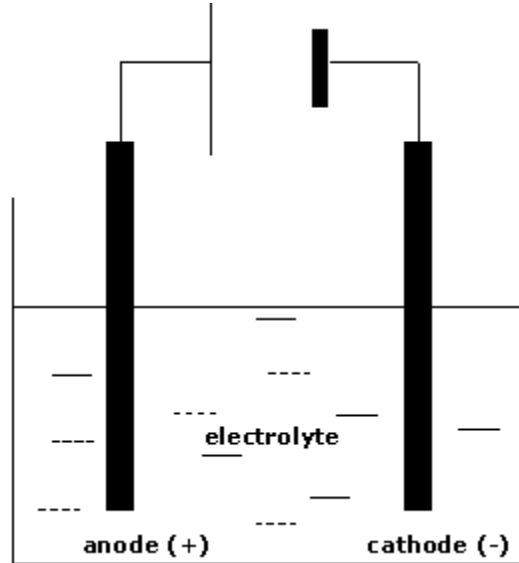
- $\text{Zn}/\text{Zn}^{2+} \parallel \text{Cu}^{2+}/\text{Cu}$
 - anode reaction
 - salt bridge is
 - cathode

Example

Write the cell notation



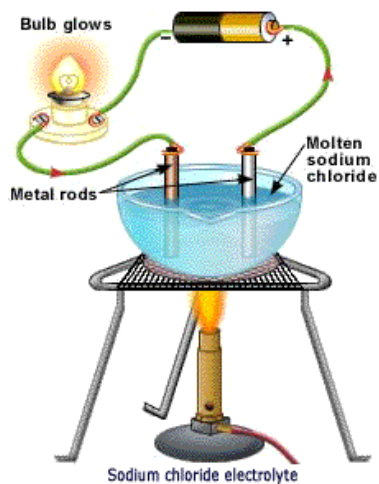
Electrolytic Cells



- An electrolytic cell is the apparatus used to pass
- The electrolytic cell has two (usually inert)
 - The negative electrode is called the
 - The inert electrodes are usually
- The reactions occur at the
- The power supply is usually symbolised
- Negative ions arrive at the anode,
- The reverse process occurs at the

Electrolysis of a Molten Salt

- Molten Ionic compounds
- The cation is attracted
- The anion is attracted
- Example molten NaCl
 - Reaction at Cathode
 - Reaction at Anode
 - Net result - one electron has been



1. Work out oxidation numbers for nitrogen in the following molecules/ions:

- a) NF_3
- b) NO
- c) N_2O
- d) N_2O_4
- e) N_2H_4
- f) NO_2^-

2. Work out the oxidation numbers of chlorine in the following species:

- a) Cl_2O
- b) HCl
- c) ClO_4^-
- d) ClF_3
- e) HClO_3

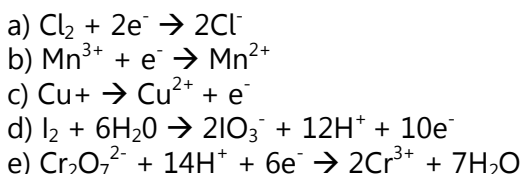
3. Work out the oxidation number of the species in bold in each of the following compounds:

- a) Na_2O
- b) KBrO_3
- c) Na_2SO_3
- d) K_2CrO_4
- e) NH_4NO_3

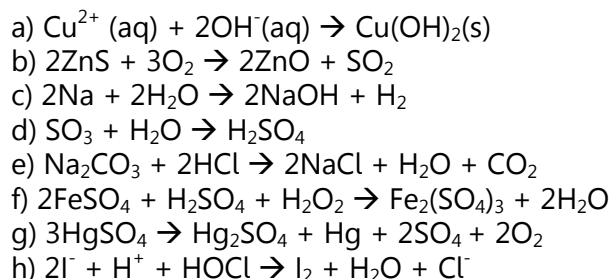
4. Work out the oxidation number of the transition metal in each of the following complex ions or compounds:

- a) $[\text{CuCl}_4]^-$
- b) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$
- c) $[\text{MnBr}_4]^{2-}$
- d) $[\text{Fe}(\text{CN})_6]^{4-}$
- e) $[\text{Ag}(\text{NH}_3)_2]^+$
- f) $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_2$

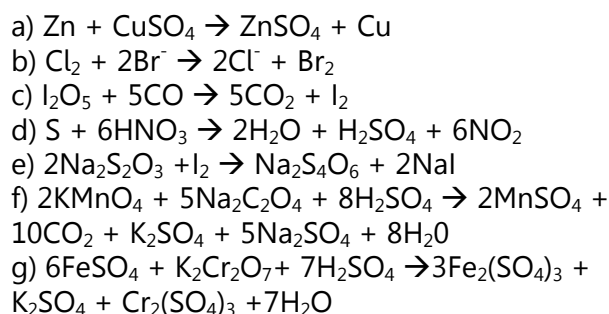
1. State whether the following half equations involve oxidation or reduction:



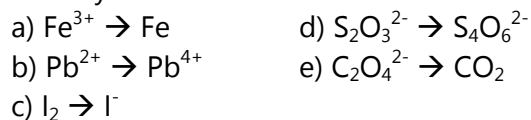
2. State which of the following reactions are redox reactions and, for each redox reaction, identify the element that has been oxidized and the element that has been reduced.



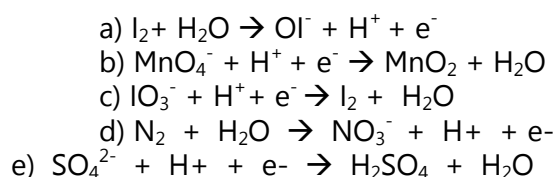
3. In each of the following redox reactions, identify the oxidizing agent and the reducing agent:



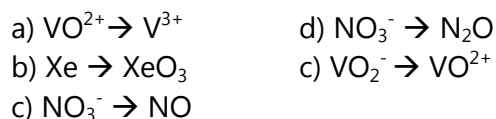
4. Balance the following half equations and identify as oxidation or reductions



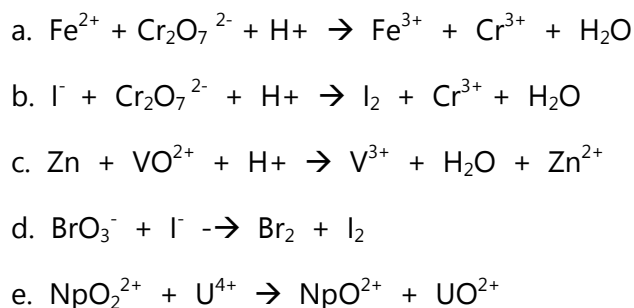
5. Balance the following half equations in acidic solution:



6. Balance the following half equations in acidic solution:



7. Balance the following redox reactions in acidic solution:



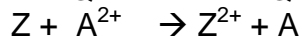
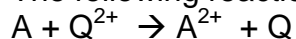
1. Consider four imaginary metals, X, Z, A and Q.

On the bases of the following data, arrange the metals X, Y, and Q in order of reactivity (most first)

Z reduces Q^{2+} to Q

X reduces Z^{2+} to Z

- a. The following reactions also occur:



- Is A a stronger or weaker reducing agent than Q
 - Arrange all four metals in order of reducing ability (strongest reducing agent first)
 - Which of the species A, A^{2+} , Z, Z^{2+} , Q, Q^{2+} , X, X^{2+} is the strongest oxidizing agent?
- b. A electrochemical cell is setup with a piece of A dipping into a solution of $A(NO_3)_2$ in one half cell and a piece of X dipping into a solution of XSO_4 in the other half cell.
- Which way do the electrons flow in the external circuit(wire)
 - The X/XSO_4 half cell is replaced with a Z/ZSO_4 half cell. Will the voltage be higher or lower than that in the original cell?

2. Draw a voltaic cell constructed of $Zn(NO_3)_2$ (aq), Zn metal, $Cu(NO_3)_2$ (aq), Cu metal and a KCl salt bridge. Indicate the cathode, anode, direction of electron flow, which direction the salt bridge will operate to balance the charge.

1. State the products at the anode and cathode when the following molten salts are electrolyzed:
 - a. Potassium bromide
 - b. Copper (II) chloride
 - c. Nickel (II) oxide
 - d. Calcium chloride

2. Write the equations for the reactions at the anode and cathode when the following molten salts are electrolyzed:
 - a. Sodium chloride
 - b. Iron (III) oxide
 - c. Magnesium bromide